FİZİKSEL TIP VE REHABİLİTASYON BİLİMLERİ DERGİSİ
Journal of Physical Medicine and Rehabilitation Sciences J PMR Sci. 2020;23(3):167-73

ORİJİNAL ARAŞTIRMA ORIGINAL RESEARCH DOI: 10.31609/jpmrs.2019-72390

Effects of Open Versus Closed Kinetic Chain Exercises in Patients with Knee Osteoarthritis

Diz Osteoartriti Olan Hastalarda Açık ve Kapalı Kinetik Zincir Egzersizlerinin Etkinliğinin Karşılaştırılması

Nuray GİRGİN[a], Arzu ATICI[b], Pınar AKPINAR[b], İlknur AKTAŞ[b], Fatma YÜKSEK[b]

[a]Department of Physiotherapy and Rehabilitation, Okan University Faculty of Health Sciences, İstanbul, TURKEY
[b]Department of Physical Medicine and Rehabilitation, University of Health Sciences, Fatih Sultan Mehmet Training and Research Hospital, İstanbul, TURKEY

This study was oral at the 27th National Physical Medicine and Rehabilitation Congress, 17-21 April 2019, Antalya, Turkey.

ABSTRACT Objective: We aimed to evaluate the effects of open versus closed kinetic chain exercises in patients with knee osteoarthritis (OA) in this study. **Material and Methods:** Thirty eight patients with knee OA were randomized into two groups as the open kinetic chain exercise (OKCE) group (n = 19) and the closed kinetic chain exercise (CKCE) group (n = 19). All subjects received physical therapy modalities including 20 minute Hot Pack (HP), 20 minute Transcuteneous Electrical Nerve Stimulation (TENS) and 20 minute Short Wave Diatermi. A total of 18 sessions were held. The CKCE and OKCE were performed 30 minutes/day under the researcher's supervision. Then the patients continued to exercise at home for 3 weeks. The Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), the Medical Outcomes Study Short Form Health Survey (SF-36) and Visual Analog Scale (VAS) were used in the assessment of the patients before and after 6 weeks of exercise programme. **Results:** We found statistically significant improvement in VAS values, WOMAC pain, physical function and total WOMAC scores and SF-36 quality of life after treatment in both OCKE and CKCE groups in patients with knee OA ($p<0.05$). When we compared the rates of change after treatment, there was no statistically significant difference between the groups ($p>0.05$). **Conclusion:** As a result, we believe that the intensity and continuity of exercise may be more important than the type of exercise in the rehabilitation of knee OA.

Keywords: Closed kinetic chain exercise; knee osteoarthrit; open kinetic chain exercise

ÖZET Amaç: Bu çalışmada diz osteoartritli (OA) hastalarda açık ve kapalı kinetik zincir egzersizlerinin etkilerini değerlendirmeyi amaçladık. **Gereç ve Yöntemler:** Diz OA'lı 38 hasta açık kinetik zincir egzersiz (OKCE) grubu (n = 19) ve kapalı kinetik zincir egzersiz (CKCE) grubu (n = 19) olarak iki gruba randomize edildi. Tüm katılımcılara 20 dakika sıcak paket (HP), 20 dakika Transcuteneous Elektrik Sinir Stimülasyonu (TENS) ve 20 dakika Kısa Dalga Diatermi tedavileri toplamda 18 seans uygulandı. Egzersizler (CKCE ve OKCE) 30 dakika/gün, araştırmacının gözetimi altında yaptırıldı. Sonraki 3 hafta boyunca aynı egzersiz programına ev programı olarak devam edildi. Hastalar, tedavi öncesi ve 6 haftalık egzersiz tedavisi sonrasında Western Ontario ve McMaster Üniversiteleri Osteoartrit İndeksi (WOMAC), Tıbbi Sonuçlar Çalışması Kısa Form Sağlık Araştırması (SF-36) ve Vizuel Analog Skalası (VAS) ile değerlendirildi. **Bulgular:** Diz OA'lı hastalarda OKCE ile CKCE grubunda tedavi sonrasında VAS değerlerinde, WOMAC ağrı, fiziksel fonksiyon ve total WOMAC skorlarında ve SF-36 yaşam kalitesi ölçeğinde istatistiksel olarak anlamlı iyileşme saptandı. Tedavi sonrası değişim oranlarını karşılaştırdığımızda gruplar arasında istatistiksel olarak anlamlı bir farklılık saptanmadı. **Sonuç:** Sonuç olarak, diz OA'nın rehabilitasyonunda, egzersizin şiddeti ve sürekliliğinin egzersiz tipinden daha önemli olabileceği kanaatindeyiz.

Anahtar Kelimeler: Kapalı kinetik zincir egzersizi; diz osteoartriti; açık kinetik zincir egzersizi

Osteoarthritis (OA), the most common form of arthritis occupies a large portion of health expenditure, with a decline in quality of life as a fundamental cause of chronic musculoskeletal pain.[1]

Patients with OA most frequently complain of pain, stiffness in joints, instability and decrease in daily living function. This creates problems in activities such as sitting-up, stair-climbing, squatting and

Correspondence: Nuray GİRGİN
Okan University Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, İstanbul, TURKEY/TÜRKİYE
E-mail: nuray.girgin@okan.edu.tr

Peer review under responsibility of Journal of Physical Medicine and Rehabilitation Science.

Received: 15 Oct 2019 ***Received in revised form:*** 25 Apr 2020 ***Accepted:*** 04 May 2020 ***Available online:*** 23 Jul 2020

walking. This situation results in a decrease in the quality of both physical and social life.[2]

Although pharmacologic, non-pharmacologic, and surgical therapeutic options are present in the treatment of knee OA, exercise is one of the most important components of cure.[3] Active modalities such as muscle strengthening exercises have been found to be effective is reducing pain, stiffness of joints and disability as well as in improving the quality of life and performance of functional tasks in patients with knee OA.[4]

Different exercise programs such as strengthening and aerobic exercises, walking programs, aquatic exercise, jogging in water, yoga, and Tai Chi exercise are applied in knee OA. However, the intensity, duration and type of physical activity that is necessary to produce improvement is still unknown.[5] The effects of exercise differ depending on the type, intensity and duration of the exercise. Open and closed kinetic chain exercises (OKCE and CKCE) have been shown to be individually effective for the improvement of quadriceps muscle strength in knee OA but it appears there is no consensus regarding the comparative effectiveness of the two exercise types.[6]

The purpose of our study is to compare the CKCE and OKCE as exercise type and to reveal the effects of regular exercise.

MATERIAL AND METHODS

A randomized controlled double-blind clinical trial was performed to compare the effects of two interventions: OKCE and CKCE exercise. In CKCE, the distal segment is stable, not moving. In the OKCE the distal segment can move freely.[7]

A total of 45 patients (32 female, 6 male) between the ages of 40 and 70 years with knee OA of 2 or 3 on the Kellgren-Lawrence classification system were enrolled in this study.[8] Of these, 7 subjects did not meet the inclusion criteria. The remaining 38 subjects completed the full of the study after being randomly assigned to the OKCE group or CKCE group. Those physically treated for knee OA within the last six months or given steroid injections to knees, with the history of knee surgery, any cardiovascular, respiratory, neurologic, or metabolic diseases that prevent exercises, and major psychiatric diseases were excluded from the study. The demographic data of the patients were recorded. Both groups continued to receive the pain medication they were taking during treatment.

Prior to the exercises, patients in both groups were informed about knee osteoarthritis and protective recommendations for the knee such as loosing weight. The exercises were applied as each movement was held for 10 seconds and 10 repetitions. The stretching movement was held for 15 seconds and 5 repetitions.

The following exercises were carried out by the participants in CKCE group:

1. Mini squat- 30 degree knee fleksion
2. Standing on one foot for 10 seconds
3. Active streching exercise for hamstring muscle for 15 seconds
4. Single toe rise
5. Wall push in the supine position

The following exercises were carried out by the participants in OCKE group:

1. Extension of knees starting from 90 degrees of knee flexion
2. Active streching exercise for hamstring muscle for 15 seconds
3. Quadriceps isometric strengthening exercise
4. Straight leg raise
5. Hamstring curl in prone

The exercises were performed 30 minutes/day under the researcher's supervision, then the patients continued to exercise at home for 3 weeks. They came to control once a week. All subjects received physical therapy modalities including 20 minute hot pack (HP), 20 minute Transcuteneous Electrical Nerve Stimulation (TENS), (The frequency is 50-100 Hz and the duration is 100 μs) and 20 minute Short Wave Diatermi (The frequency is 27.12 MHz and a wave length is 11m). A total of 18 sessions were held.

Knee pain was measured using Visual Analog Scale (VAS) on which the patients could grade their pain from '0' (no pain at all) to '10'(the most severe

pain imaginable) at rest and movement.[9] The Western Ontario and McMaster Universities Osteoarthritis (WOMAC) index which is a disease-specific self-administered questionnaire developed to study patients with hip or knee OA was used for the assessment of disability.[10]

The Medical Outcomes Study Short Form Health Survey (SF-36) which consists of physical function, physical role, bodily pain, general health, vitality, social function, emotional role and mental health subparameters were used for assessment of quality of life.[11] Pre- and post-treatment evaluations were done by the same researcher before and after 6 weeks of exercise programme.

This study was approved by the ethics committee of the Fatih Sultan Mehmet Training and Research Hospital in Istanbul and all the patients signed an informed consent form before they were included.

POWER ANALYSIS

For the amount of change observed in the WOMAC parameter as a result of the power analysis using the G Power program, the number of samples detected for Power: 0.80 and 0.05 when the effect size d (effect size) was 1.23 and SD: 0.4 was found to be minimum n: 12 for each group.

STATISTICAL ANALYSIS

For the statistical analyzes the IBM SPSS Statistics 22 (IBM SPSS. Turkey) program was used. When the study data were evaluated, the normal distribution of the parameters was evaluated by the Shapiro Wilks test. Student t test was used for comparison between the two groups of normal distribution parameters. Mann Whitney U test was used for comparison between the two groups, while descriptive statistical methods (mean, standard deviation, frequency) as well as quantitative data were evaluated. Paired Samples t test was used for intra-group comparison of normally distributed parameters and Wilcoxon Signed Ranks test was used for intra-group comparison of non-normally distributed parameters. Significance was assessed at $p<0.05$.

RESULTS

We compared OKCE with CKCE in knee OA. The study consisted of 38 cases, aged between 40 to 70 years, including 6 (15.8%) men and 32 (84.2%) women. The mean age was 58.29±7.27 years. The body mass index (BMI) values ranged from 24.92 to 41.91 kg/m² with a mean of 31.01±4.33.

There aren't any difference regarding the demographic values between the OKCE group and CKCE group at baseline (Table 1).

The resting-right and left knee values of the pre-treatment VAS of the OKCE group were higher than those of the CKCE group. The movement-right and left knee values of the pre-treatment VAS weren't different. There was a significant decrease in VAS values at rest and movement after treatment in both groups (Table 2). When we compared the rates of change after treatment, there was no statistically significant difference between the groups in VAS values ($p>0.05$).

Pre-treatment pain and physical function parameters were the same in both groups. But pre-treatment stifness and total WOMAC parameters in OKCE group were higher than CKCE group. There was a significant decrease in pain, physical function and

TABLE 1: Demographics and characteristics of OKCE and CKCE groups.

	OKCE group (n:19) (mean±sd)	CKCE group (n:19) (mean±sd)	p
Age (year)	56.75±7.8	59.84±6.54	0.192
BMI (kg/m²)	32.03±4.34	29.99±4.19	0.149
Duration of complaint (year) (median)	4.13±4.04	6.17±7.6 (5)	0.548
Gender (n) (%)			
Female	15 (78.9)	17 (89.5)	0.660
Male	4 (21.1)	2 (10.5)	

BMI: Body-mass index, *p<0.05.

TABLE 2: Evaluation of VAS values before and after treatment between and within groups.

		OKCE group (n=19)	CKCE group (n=19)	
VAS		**Mean±SD**	**Mean±SD**	**p[1]**
Rest-Right Knee	BT	5.79±3.26 (6)	3.63±3.25 (5)	0.045*
	AT	3.16±2.73 (3)	1.74±2.21 (0)	0.089
	p[2]	0.001*	0.013*	
Movement-Right Knee	BT	5.95±2.91 (6)	6.05±2.93 (6)	0.895
	AT	4.26±2.84 (5)	3.37±2.54 (4)	0.302
	p[2]	0.003*	0.001*	
Rest-Left Knee	BT	5.74±2.62 (5)	3.32±3.33 (3)	0.016*
	AT	2.63±2.83 (3)	1.68±2 (1)	0.376
	p[2]	0.001*	0.015*	
Movement-Left Knee	BT	6±2.75 (6)	5.68±2.65 (6)	0.780
	AT	3.79±2.51 (4)	3.42±2.34 (3)	0.535
	p[2]	0.002*	0.002*	

AT: After treatment; BT: Before treatment; VAS: Visual Analog Scale, *p<0.05.

p[1]: Comparison of VAS values of OKCE and CKCE groups. p[2]: Comparison of pre-treatment and post-treatment VAS values within groups.

total WOMAC parameters after treatment in both groups (Table 3). When we compared the rates of change after treatment, there was no statistically significant difference between the groups in all WOMAC parameters (p>0.05).

Pre-treatment SF-36 values were the same except for general health perception and mental health in both groups. There was a significant difference only in general health perception among the groups after treatment (p<0.05).

In OKCE group, improvements were obtained in all parameters except vitality after treatment. In CKCE group, improvements were obtained in other parameters except mental health, social functioning and role-physical after treatment (Table 4). When we compared the rates of change after treatment, there

TABLE 3: Evaluation of WOMAC values before and after treatment between and within groups.

		OKCE group (n=19)	CKCE group (n=19)	p[1]
WOMAC		**Mean±SD**	**Mean±SD**	
Pain	BT	11.68±4.85	8.79±4.14	0.056
	AT	5.37±3.64	4.53±3.64	0.480
	p[2]	0.001*	0.001*	
Stiffnees	BT	4.21±2.23	2.58±2.34	0.034*
	AT	3.21±1.96	2.26±1.85	0.134
	p[2]	0.100	0.500	
Physical Function	BT	35.47±13.67	27±14.7	0.074
	AT	18.79±10.29	15.68±11.38	0.384
	p[2]	0.001*	0.001*	
Total	BT	51.37±19.12	38.32±19.67	0.045*
	AT	27.16±14.27	22.37±16	0.337
	p[2]	0.001*	0.001*	

AT: After treatment; BT: Before treatment; WOMAC: The Western Ontario and McMaster Universities Osteoarthritis Index.*p<0.05.

p[1]: Comparison of WOMAC values of OKCE and CKCE groups. p[2]: Comparison of pre-treatment and post-treatment WOMAC values within groups.

TABLE 4: Evaluation of SF-36 values before and after treatment between and within groups.

		OKCE group (n=19)	CKCE group (n=19)	p[1]
SF-36		**Mean±SD**	**Mean±SD**	
Physical function	BT	42.22±16.74	50.26±17.36	0.161
	AT	57.78±14.17	61.58±15.73	0.446
	p[2]	0.002*	0.033*	
Role-physical	BT (median)	19.44±27.86 (0)	42.11±40.01 (25)	0.056
	AT (median)	44.44±38.88 (50)	53.95±37.51 (50)	0.455
	p[2]	0.015*	0.107	
Bodily pain	BT(median)	31.33±21.14 (41)	39.11±22.81 (32)	0.359
	AT(median)	59.28±23.9 (62.5)	65.26±27.27 (61)	0.482
	p[2]	0.001*	0.002*	
General health perception	BT	38.61±23.29	55.05±24.43	0.044*
	AT	49.11±23.71	64.95±23.44	0.049*
	p[2]	0.032*	0.040*	
Vitality	BT	41.39±25.66	40.26±20.91	0.884
	AT	46.94±23.4	56.32±27.02	0.268
	p[2]	0.337	0.023*	
Social function	BT	53.94±26.01	66.89±31.89	0.186
	AT	70.67±21.04	75.47±27.52	0.556
	p[2]	0.011*	0.115	
Role-emotional	BT(median)	31.28±33.19 (33)	43.68±41.61 (33)	0.417
	AT(median)	60.89±40.02 (66)	73.42±32.62 (66)	0.365
	p[2]	0.010*	0.016*	
Mental health	BT	51.56±28.87	68.84±21.73	0.046*
	AT	66.89±19.73	73.89±18.49	0.272
	p[2]	0.004*	0.112	

AT: After treatment; BT: Before treatment; SF/36: The Medical Outcomes Study Short Form Health Survey. *p<0.05.

p[1]: Comparison of SF-36 values of OKCE and CKCE groups. p[2]: Comparison of pre-treatment and post-treatment SF-36 values within groups.

was no statistically significant difference between the groups except in general health perception (p>0.05).

DISCUSSION

Exercise is a commonly prescribed and effective treatment for patients with knee OA. Many questions still remain regarding the type and format of exercises.[12] OKCE and CKCE are used extensively in lower extremity disorders. However, there are very few studies in the literature regarding the comparison of OKCE and CKCE in knee OA. In this study, we compared the effect of OKCE and CKCE in patients with knee OA.

We felt the need to compare the efficacy of OKCE and CKCE that were widely used in patients with knee OA, since it appears there is no consensus regarding the comparative effectiveness of the two exercise types. Elniel et al. found that both OKCE and CKCE have an equal effect on the architecture of the vastus medialis oblique after six weeks of exercise program.[13] Another study comparing OKCE and CKCE with hot pack in knee osteoarthritis showed that CKCE is more effective than OKCE for improving quadriceps strength and functional status of women with knee OA.[14] In our study, pain, stiffness, physical function, and general perception values of WOMAC between groups weren't different, while intra-group values were found significantly different in both groups. Between pre-post treatment we found a decrease in pain, an increase in physical function and improvements in total values of WOMAC in both of the groups. Stiffness has not changed at all. So, we

suggest that it is more important to exercise extensively than the type of exercise.

Kirihara et al. explored whether there was a correlation between type, intensity, and duration of physical activity required to improve function in knee OA. They suggest that patients with knee OA should aim for intense physical activity and/or more than 180 minutes of exercise per week and/or weight training for relevant pain reduction and functional improvement.[6] In our study, exercise session was given 30 minutes per day, so on average 180 minutes per week as Kirihara et al. We think that one of the reason for improvement in both groups was the intensity of exercise.

We focused on the comparison of the efficacy of OKCE and CKCE for pain, stiffnees, physical function and quality of life in our study. In a meta-analysis of 48 randomized controlled trials with a total of more than 4.000 patients, exercise therapy programs focusing on a single type of exercise were found to be more efficacious in reducing pain and patient-reported disability than those mixing several types of exercise in knee OA.[5] Daşkapan et al. compared the effects of straight leg raise exercise and mini squat exercise on pain intensity, performance, muscle strength, physical function, and balance in patients with knee OA. They suggested that exercise type should be selected according to each patient's clinical characteristics, limitations, needs, and interests.[4]

Gbiri et al. compared the effects of OKCE and CKCE on proprioception, muscles strength, and functional performance in individuals with knee OA.[15] They found that the CKCE group showed significantly better improvement than the OKCE group in physical function, energy, role limitation, pain, and osteoarthritis severity. In our study improvement was found in the parameters of pain, physical function, general health perception, emotional role strength of SF/36 in both exercise groups. But, there wasn't any improvement in role-physical, vitality and mental health parameters in the CKCE group, and vitality parameter in the OKCE group. There are many variables that influence the quality of life. It is very difficult to control them. We believe that this situation affected the SF/36 parameters in our study.

CONCLUSION

We found no difference between the efficacy of OKCE and CKCE for pain, pysical function, and quality of life in patients with knee OA. On the other hand, we found a statistically significant improvement in VAS values, WOMAC pain, physical function and total WOMAC scores and SF-36 quality of life after treatment in both groups. As a result, our study suggests that intensity and continuity of the exercise are more effective than exercise type for significant improvement in knee OA.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

REFERENCES

1. Iwamoto J, Sato Y, Takeda T, Matsumoto H. Effectiveness of exercise for osteoarthritis of the knee: a review of the literatüre. World J Orthop. 2011;5:37-42. [Crossref] [PubMed] [PMC]
2. Bilgiç A, Kamiloğlu R, Tuncer S. [The effectiveness of izokinetic exercise program on knee osteoarthritis]. J PMR Sci. 2007;3:70-5.
3. Yılmaz H, Polat HAD, Karaca G, Küçükşen S, Akkurt HE. Effectiveness of home exercise program in patients-with knee osteoarthritis. Eur J Gen Med. 2013;10(2):102-7. [Crossref]
4. Daşkapan A, Anaforoğlu B, Özünlü Pekyavaş N, Tüzün EH, Nur Coşar S, Karataş M. Comparison of mini-squats and straight leg raises in patients with knee osteoarthritis: a ranomized domized controlled clinical trial. Turk J Rheumatol. 2013;28(1):16-26. [Crossref]
5. Juhl C, Christensen R, Roos EM, Zhang W, Lund H. Impact of exercise type and dose on pain and disability in knee osteoarthritis: a systematic review and meta-regression analysis of randomized controlled trials. Arthritis Rheumatol. 2014;66(3):622-36. [Crossref] [PubMed]
6. Kirihara RA, Catelan FB, DE Farias FES, DA Silva CAC, Cernigoy CHDA, Rezende MUD. Intensity, duration and type of physical activity required to improve function in knee ostoearthritis. Acta Ortop Bras. 2017;25(1):25-9. [Crossref] [PubMed] [PMC]
7. Escamilla RF, Fleisig GS, Zheng N, Barrentine SW, Wilk KE, Andrews JR. Biomechanics of the knee during closed kinetic chain and open kinetic chain exercises. Med Sci Sports Exerc. 1998;30(4):556-69. [Crossref] [PubMed]

8. Kellgren JH. Lawrence JS. Radiological assessment of osteo-arthrosis. Ann Rheum Dis. 1957;16(4):494-502. [Crossref] [PubMed] [PMC]
9. Price DD, McGrath PA, Rafii A, Buckingham B. The validation of visual analogue scales as ratio scale measures for chronic and experimental pain. Pain. 1983;17(1):45-56. [Crossref]
10. Tüzün EH, Eker L, Aytar A, Daşkapan A, Bayramoğlu M. Acceptability, reliability, validity and responsiveness of the Turkish version of WOMAC osteoarthritis index. Osteoarthritis Cartilage. 2005;13(1):28-33. [Crossref] [PubMed]
11. Koçyiğit H, Aydemir Ö, Fişek G, Ölmez N, Memiş A. Kısa Form-36 (KF-36)'nın Türkçe versiyonunun güvenilirliği ve geçerliliği: romatizmal hastalığı olan bir grup hasta ile çalışma. İlaç ve Tedavi Dergisi. 1999;12(2):102-6.
12. Roddy E, Zhang W, Doherty M, Arden NK, Barlow J, Birrell F, et al. Evidence-based recommendations for the role of exercise in the management of osteoarthritis ofthe hip or knee--the move consensus. Rheumatology (Oxford). 2005;44(1):67-73. [Crossref] [PubMed]
13. Elniel AR, Robertson C, Killingback A, Adds PJ. Open-chain and closed-chain exercise regimes: an ultrasound investigation into the effects of exercise on the architecture of the vastus medialis oblique. Physical Therapy and Rehabilitation. 2017;4(1):3. [Crossref]
14. Verma S. Comparing open kinetic chain with closed kinetic chain exercise on quadriceps strength and functional status of women with osteoarthritic knees. Romanian Sports Medicine Society. 2012;8(4):1989-96.
15. Gbiri CA, Okafor UAC, Alade MT. Comparative efficacy of open-chain and close-chain kinematics on proprioception, muscles' strength and functional performances in individual with knee osteoarthritis. Occup Med Health Aff 2013;1(1).